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(21) Patentansökningsnummer / Patent application number — *0300446-2*

(86) Ingivningsdatum / Date of filing — *2003-02-18*

Stockholm, 2003-09-05

För Patent- och registreringsverket
For the Patent- and Registration Office

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Avgift
Fee 170:-

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An implantable heart stimulating device, a system including such a device and use of the system

BACKGROUND OF THE INVENTION

1. Field of the invention

The present invention relates to an implantable heart stimulating device with which it is possible to stimulate both the ventricles of a heart, i.e. a bi-ventricular pacer.

The invention also relates to a system including such a device and to the use of the system.

2. Description of the prior art

Several different implantable devices for stimulating a heart are known. The devices are normally able to sense the electrical activity of the heart. Some implantable devices are able to deliver stimulation pulses to both the left and right ventricles of the heart, and sometimes also to the left and right atria.

Devices that are able to deliver stimulation pulses to both the left and right ventricles are also called bi-ventricular pacers. Such devices can be used to treat patients who suffer from different severe cardiac problems, e.g. patients suffering from congestive heart failure (CHF). CHF is defined generally as the inability of the heart to deliver a sufficient amount of blood to the body. CHF can have different causes. It can for example be caused by a left bundle branch block (LBBB) or a right bundle branch block (RBBB). By for example using bi-ventricular pacing, the contraction of the ventricles can be controlled in order to improve the ability of the heart to pump blood. The stimulation pulses to the two ventricles can be delivered simultaneously but it is also known that the stimulation pulses to the

two ventricles are delivered with a short time delay (VV) between them in order to optimise the pumping performance of the heart.

US-A-5 720 768 describes different possible electrode positions in order to stimulate or sense the different chambers of the heart.

US-A-6 070 100 describes that electrodes may be positioned in both the left and the right atrium as well as in the left and the right ventricles.

Another phenomenon known in connection with heart stimulation devices (pacers) is a premature ventricular contraction (PVC). A PVC means, as the expression suggests, that the ventricle in question contracts too early. The occurrence of PVCs can lead to unwanted consequences in pacers. For example, a PVC may be sensed by an electrode located in the atrium and thereby be interpreted by the pacer as an atrial event. This may cause so-called pacemaker mediated tachycardia (PMT). This problem has been solved in different manners in pacers of the “traditional” kind that has means for sensing and pacing the right atrium and the right ventricle. One known manner of treating this problem, is that the pacer, when detecting a PVC, initiates an extended post ventricular atrial refractory period (sometimes designated +PVARP), i.e. a period during which the atrial channel‘s sensing is unresponsive.

In bi-ventricular pacers, the situation is more complex, since this kind of pacer usually comprises more sensing and pacing electrodes, and that therefore, more signals are detected or generated by the pacer. It is however known that PMT is prevented also in bi-ventricular pacers. The document US 2002/0183792 A1 describes a pacer with an extended PVARP-function, in which a certain ventricular blanking period (designated 430 in the document) is used to prevent an unwanted dual PVC response, which could otherwise occur in a bi-ventricular pacer.

It should also be mentioned that there exist different manners of operating a bi-ventricular pacer. When an event is detected in one

ventricle it is thus possible to immediately deliver a pacing pulse to the same ventricle or only to the other ventricle or to both ventricles. Sometimes the pacing pulse to the other ventricle is delivered with a time delay (VV), if that ventricle is the ventricle that should be paced later than the first ventricle. For example US-A-6 466 820 discusses different pacing modes (see in particular column 15, lines 24-39). According to this document, in one manner of operating the device, also a PVC (if it arrives sufficiently late in the cardiac cycle) causes a pacing pulse to be delivered to the other ventricle with the normal programmed VV-delay. However, the document does not disclose any separate time interval for the treatment of PVCs.

SUMMARY OF THE INVENTION

Even if PMT caused by sensing a PVC in an atrium is prevented in accordance with the prior art, a PVC may still cause arrhythmic problems. For, for example, a patient suffering from a conduction block (for example a LBBB or a RBBB) PVCs can cause ventricular arrhythmia. Because of the block, the left and right ventricle do not depolarise synchronously as in a healthy heart. Since a PVC means that a depolarisation takes place earlier than normally, a more complex situation with different degrees of depolarisation in different parts of the heart takes place. This increases the likelihood of arrhythmic episodes.

The present invention concerns a bi-ventricular pacer of the following kind.

An implantable heart stimulating device including a control circuit comprising:

first pacing means adapted to be connected to a first pacing electrode suited to be positioned in or at a first ventricle of a heart such that said first pacing means are able to deliver pacing pulses to said first pacing electrode in order to be able to pace said first ventricle;

first sensing means adapted to be connected to a first sensing electrode suited to be positioned in or at said first ventricle of the heart so as to transfer signals to said first sensing means such that said first sensing means are able to sense said first ventricle;

second pacing means adapted to be connected to a second pacing electrode suited to be positioned in or at a second ventricle of the heart such that said second pacing means are able to deliver pacing pulses to said second pacing electrode in order to be able to pace said second ventricle;

second sensing means adapted to be connected to a second sensing electrode suited to be positioned in or at said second ventricle of the heart so as to transfer signals to said second sensing means such that said second sensing means are able to sense said second ventricle;

said control circuit being arranged to be able to operate with time cycles corresponding to normal heart cycles;

said control circuit being arranged to be able to operate with a first time delay (VV) and to, within one and the same of said time cycles, being able to first pace and/or sense with said first pacing means or said first sensing means and then deliver a pacing pulse with said second pacing means with said first time delay;

said control circuit also being arranged to include a criterion with which a signal that is sensed by said first or second sensing means, and which fulfils said criterion, is characterised as belonging to a first category of signals typical for a premature ventricular contraction.

An object of the present invention is to reduce the risk for arrhythmia in a bi-ventricular heart stimulating device of this kind. A more particular object is to reduce the risk for arrhythmia which may be caused by PVCs in such a heart stimulating device. A further object is to provide such a heart stimulating device, in which, in addition to reducing the risk for such an arrhythmia, also the hemodynamic performance of the heart is favoured in case of PVCs. Further objects and advantages of the invention will become clear from the description below.

The above objects are achieved by an implantable heart monitoring device of the above mentioned kind, which is characterized in that the control circuit is also arranged to operate with a second time delay (VV_{PVC1}) and/or a third time delay (VV_{PVC2}), and to, within one of said time cycles, being able to first sense with one of said first and second sensing means and then, at least if a predefined pacing rule is fulfilled, deliver a pacing pulse, with said second time delay (VV_{PVC1}) with the second pacing means if the sensing was done with said first sensing means or with said third time delay (VV_{PVC2}) with the first pacing means if the sensing was done with said second sensing means.

The device is thus arranged to operate with a first time delay VV but also with at least one additional time delay, VV_{PVC1} and/or VV_{PVC2}. The first time delay can be set to optimise the synchronisation of the contraction of the ventricles. With the first time delay VV, the hemodynamic performance of the heart may thus be optimised. The second and/or third time delays can be set to a different value than VV. The second and/or third time delays may be set to reduce the risk for arrhythmia in certain situations. In particular, as has been described above, a PVC may cause a ventricular arrhythmia. In order to reduce the risk for such an arrhythmia, it is important to try to avoid a situation where the ventricles are in different states concerning depolarisation. By setting an appropriate VV_{PVC1} and/or VV_{PVC2}, the depolarisation of the two ventricles can be optimised such that they appear synchronously. Thereby, the likelihood of arrhythmia is reduced. It should be pointed out that the best time delay for achieving simultaneous contraction of the ventricles may not be the same as the optimal time delay in order to synchronise the depolarisation of the ventricles. Therefore, according to the present invention, since the second and/or third time delays VV_{PVC1}, VV_{PVC2} can be set to be different than the first time delay VV, the operation of the device is optimised in order to reduce the risk for arrhythmia at the same time as the device, in its normal operation, is optimised for synchronising the contraction of the ventricles.

Preferably, the device is programmable such that a physician can program the first and the second and/or third time delays. In a particular situation, it could happen that a time delay is equal to zero. However, preferably both the first and at least one of the second and third time delays are not equal to zero.

It should also be pointed out that because of hardware reasons, even if a time delay is actually "set" to be zero, there may be a very small time between the delivered pulses to the two ventricles. When in this document it is said that a time delay is not equal to zero, it is thus meant that the time delay is purposely made longer than the minimum necessitated by the hardware.

It should be noted that the mentioned first ventricle can be either the left ventricle or the right ventricle. As is clear from claim 1, if the device is operated with a first time delay VV, then the ventricle to which a pacing pulse is delivered with said first time delay is designated the second ventricle. The first ventricle is thus the ventricle that is paced first in case pacing pulses are delivered to both the ventricles.

It should also be mentioned that it is also possible that the device is arranged with two different values of said first time delay VV. A first value of VV may be the case if the first ventricle is sensed and a second value of the time delay VV can be used if the first ventricle is paced. However, for the sake of simplicity it is below not further discussed that the first time delay in fact could have two different values.

Preferably, each of said first, second and third time delays is shorter than 80ms, most preferable shorter than 40 ms. Such lengths of the mentioned time delays are normally beneficial in order to synchronise the contraction of the ventricles or to reduce the risk for arrhythmia in case of a PVC.

The first time delay is preferably different from one or both of the second and third time delays. In particular, it is preferred that the

first time delay is longer than the second and/or third time delay. In order to synchronise the depolarisation of the two ventricles, the optimal time delay is normally shorter than the time delay for synchronising the contraction of the ventricles.

According to a preferred embodiment, the control circuit is arranged to be able to perform the following steps:

determine whether a signal sensed by said first or second sensing means belongs to said first category, and, if this is the case, deliver a pacing pulse, in accordance with said predefined pacing rule, with said first pacing means if said signal in said first category was sensed by said second sensing means and with said second pacing means if said signal in said first category was sensed by said first sensing means. When a signal typical of a PVC is detected by for example the first sensing means, a pacing pulse is delivered with the second pacing means. In this manner, the depolarisation of the ventricles can be synchronised. At the same time also the hemodynamic performance is improved, since also the contraction of the ventricles, in case of a PVC, is likely to be more synchronised than if no such pacing pulse were delivered with said second pacing means.

Preferably, if said signal in said first category is sensed by said first sensing means, then the pacing pulse delivered with said second pacing means is delivered with said second time delay (VV_{PVC1}). The second pacing means can be used to pace the second ventricle. The occurrence in time of the pacing pulse delivered with the second pacing means is optimised since it is delivered with the second time delay as has been described above. Analogously, if the signal in said first category is sensed by said second sensing means, then the pacing pulse delivered by said first pacing means is delivered with said third time delay (VV_{PVC2}).

According to one embodiment, after that said signal in said first category is sensed by said first sensing means, the control circuit monitors whether a corresponding signal is sensed by said second sensing means, and if such a signal is sensed by said second

sensing means during said second time delay (VV_{PVC1}), then the delivery of said pacing pulse with said second pacing means is inhibited. If a signal is sensed by the second sensing means during the second time delay, then it is not necessary to deliver a pacing pulse with said second pacing means. Consequently, such a pacing pulse can be inhibited. Analogously, after that a signal in said first category is sensed by said second sensing means, the control circuit can monitor whether a corresponding signal is sensed by said first sensing means, and if such a signal is sensed by said first sensing means during said third time delay (VV_{PVC2}), then the delivery of said pacing pulse with said first pacing means is inhibited.

According to another embodiment, if a signal is sensed by said second sensing means, then the pacing pulse delivered with said first pacing means is delivered immediately (i.e. the third time delay VV_{PVC2} is at least substantially equal to 0) upon sensing with the second sensing means. Since the pacing pulse should normally be delivered first with the first pacing means, it can be advantageous to deliver this pacing pulse as soon as possible in case the second sensing means senses a signal.

The device can also comprise means adapted to be able to sense and/or pace an atrium of said heart. It is well known to a person skilled in the art that it is often advantageous to arrange the device with means adapted to be able to sense and/or pace also one or both the atria of the heart.

According to a preferred embodiment, the mentioned criterion for categorising a signal in the mentioned first category is that either a signal is sensed by said first sensing means after a previous sensed or paced or inhibited event relating to said first sensing or pacing means without any intermediate sensed or paced event by said means for sensing and pacing an atrium or that a signal is sensed by said second sensing means after a previous sensed or paced or inhibited event relating to said second sensing or pacing means without any intermediate sensed or paced event by said means for sensing and pacing an atrium. This is one practical way

of categorising a signal as a suspected PVC. Such a manner of detecting a PVC-signal is known in the art. However, the invention is not limited to this particular embodiment. It may also be possible to categorise a signal as a PVC by other criteria, such as the occurrence of a signal within a certain time window. Another possible criterion for categorising a signal as a PVC is that the signal morphology fulfils certain predetermined morphology criteria, such as signal duration or sequence of peaks.

According to another aspect of the invention, the invention provides an implantable heart stimulating system comprising a device according to any of the above embodiments and a first and a second lead connected to said device, wherein said first pacing electrode is arranged on said first lead and said second pacing electrode is arranged on said second lead. Preferably, said first sensing electrode is the same electrode as said first pacing electrode and said second sensing electrode is the same electrode as said second pacing electrode. With such a system, the advantages described above are achieved.

According to another aspect, the invention concerns a use of such a system. According to this use, the system is implanted in a human or animal being, wherein said first pacing electrode is positioned in or at a first ventricle of the heart of said human or animal being and wherein said second pacing electrode is positioned in or at the second ventricle of said heart.

The heart stimulating system is preferably used to react to a premature ventricular contraction such that the risk for arrhythmia is reduced. The system can be used on a human or animal being suffering from congestive heart failure, for example when said human or animal being suffers from a bundle branch block.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig 1 shows schematically a heart stimulating system with a heart stimulating device connected to leads with sensing and pacing electrodes positioned in a heart.

Fig 2 shows schematically a control circuit which may form part of the device.

Fig 3 A shows schematically a signal sequence in a first situation of operating the device.

Fig 3 B shows schematically a similar signal sequence in a second situation of operating the device.

Fig 4 shows a schematic flow chart concerning the operation of the device.

DESCRIPTION OF PREFERRED EMBODIMENTS

Fig 1 shows schematically an implantable heart stimulating device 10 according to the invention. The device 10 comprises a housing 12. The device 10 includes a control circuit 14 (that will be described more in connection with Fig 2). The device 10 has a connector portion 13. The device 10 is in the illustrated embodiment connected to different leads 30, 40, 50, 60.

Fig 1 also schematically shows a heart including a right atrium RA, a left atrium LA, a right ventricle RV and a left ventricle LV.

A first lead 30 includes electrode members 31, 32 positioned in the right ventricle RV of the heart. The electrode member 31 may be called tip electrode and the electrode member 32 can be called a ring electrode. In this example, the first lead 30 thus includes a bipolar electrode. However, it is within the scope of the invention that the device 10 instead is connected to unipolar electrodes as is known to a person skilled in the art. The electrode 31, 32 constitutes a first sensing electrode 31, 32 suited to sense cardiac events related to a first ventricle 1V (in this case the right ventricle RV). The electrode 31, 32 also functions as a first pacing electrode 31, 32 for delivering pacing pulses to the first ventricle 1V.

A second lead 40 is connected to the device 10. The second lead 40 includes in the shown embodiment bipolar electrode 41, 42. This electrode constitutes a second sensing electrode 41, 42 positioned for sensing events related to the second ventricle 2V (in this case the left ventricle LV). The electrode 41, 42 also constitutes a second pacing electrode 41, 42 for delivering pacing pulses to the second ventricle 2V. The second lead 40 may for example be introduced via the right atrium and the coronary sinus such that the electrode 41, 42 is positioned in for example the middle or great cardiac vein of the heart. How to introduce the second lead 40 in this manner is known to a person skilled in the art.

According to the shown embodiment, the device is also connected to a third lead 60 with a bipolar electrode 61, 62. This electrode is positioned in the right atrium RA in order to be able to sense and pace this atrium. The device 10 is in this case also connected to a fourth lead 50 with a bipolar electrode 51, 52. This electrode may be positioned in the coronary sinus in order to sense and pace the left atrium LA of the heart. According to an alternative embodiment the electrode 41, 42 and the electrode 51, 52 could be arranged on one and the same lead.

The device 10 together with at least two leads 30, 40 thus constitute an implantable heart stimulating system according to the invention.

Fig 2 shows schematically the control circuit 14 in some more detail. The control circuit 14 includes at least one memory 15. Furthermore, the control circuit 14 comprises first sensing means 16 and first pacing means 18. These means are adapted to be connected to the first lead 30 in order to sense and pace a first ventricle 1V. The means 16, 18 are also connected to a control portion 20 of the control circuit 14.

The control circuit 14 also includes second sensing means 17 and second pacing means 19. These means 17, 19 are adapted to be connected to the second lead 40 in order to sense and stimulate the

second ventricle 2V. The means 17, 19 are also connected to the control portion 20 of the control circuit 14.

The control circuit 14 illustrated in Fig 2 also comprises third sensing means 22 and third pacing means 24. These means 22, 24 are adapted to be connected to the third lead 60 in order to sense and pace the right atrium RA. The control circuit 14 also includes fourth sensing means 23 and fourth pacing means 25. These means 23, 25 are adapted to be connected to the fourth lead 50 in order to sense and pace the left atrium LA.

Since a control circuit 14 for controlling a pacer is well known to a person skilled in the art, no further details need to be described here. Fig 2 only functionally shows some of the parts of the control circuit 14 and the control circuit 14 does not necessarily have to be designed in the manner indicated in Fig 2. The control circuit 14 may of course include several other parts. For example the control circuit 14 can be arranged to control the heart stimulating device 10 by sensing the level of physical activity of the living being into which the device 10 is implanted. Furthermore, the control circuit 14 can be arranged such that it can communicate via so-called telemetry with an external device. The control circuit 14 may also for example include means for delivering defibrillation signals. It may also be noted that the control circuit 14 may include several different memories, such as a RAM and a ROM.

The control circuit 14 is arranged to be able to operate with time cycles corresponding to normal heart cycles. This can be done by detecting signals typical for certain events in the heart and/or by preset timer intervals as is known to a person skilled in the art.

The control circuit 14 is arranged to detect R-waves (i. e. a QRS complex) in the two ventricles with the help of the means 16, 17. The control circuit 14 can be arranged to detect such R-waves in a certain window, but preferably the control circuit 14 is arranged to continuously monitor the respective ventricle 1V, 2V for the detection of R-waves, except for during short blanking periods. Normally,

the control circuit 14 is also arranged to have a ventricular refractory period after the sensing of an R-wave (or after the delivery of a pacing pulse).

The control circuit 14 can also be arranged to detect P-waves with the help of the means 22 and/or 23.

The control circuit 14 is also arranged to be able to operate with a first time delay VV. Within one and the same time cycle, the device 10 may thus first pace and/or sense with the first pacing means 18 or the first sensing means 16 and then deliver a pacing pulse with the second pacing means 19 at the time out of said first time delay VV. Such an operation is known in connection with bi-ventricular pacers. Thereby, the contraction of the ventricles can be synchronised.

The control circuit 14 is also arranged to categorise a signal as belonging to a first category. The first category of signals represents signals which are typical for a PVC. A signal can be categorised as a PVC-signal in different manners, for example by the fact that a sensed ventricular event is not preceded by a sensed or paced atrial event in the time cycle in question. This can be detected by the fact that a ventricular event is sensed after a previous sensed or paced or inhibited ventricular event in the same ventricle without an intermediate sensed or paced event relating to an atrium.

Another manner of detecting a PVC is by the fact that a sensed ventricular event is sensed after a previous sensed and/or paced ventricular event relating to any of the ventricles. According to this manner of detecting a PVC, the pacer should preferably be programmed with a refractory period of, for example, between 300ms and 350ms after a first sensed or paced event in a ventricle in order not to interpret a sensed event in the other ventricle within this refractory period as a PVC. Once such a PVC has been detected, the mentioned refractory period can be disabled in order to allow for sensing during the below described second and third time delays VV_{PVC1} and VV_{PVC2}.

Another possible criterion for categorising a signal as a PVC is that the signal morphology fulfils certain predetermined morphology criteria, such as signal duration or sequence of peaks.

In addition to the mentioned first time delay VV, the control circuit 14 is also arranged to operate with a second time delay VV_{PVC1} and/or with a third time delay VV_{PVC2}. The device is arranged such that within one and the same time cycle, it is able to first sense with one of said first (16) and second (17) sensing means and then, at least if a predefined pacing rule is fulfilled, deliver a pacing pulse, with said second time delay (VV_{PVC1}) with the second pacing means (19) if the sensing was done with said first sensing means (16) or with said third time delay (VV_{PVC2}) with the first pacing means (18) if the sensing was done with said second sensing means (17).

The first time delay VV, the second time delay VV_{PVC1} and the third time delay VV_{PVC2} are preferably programmable independently of each other. The device may for example be arranged such that a physician can program these delays with the help of so-called telemetry. Each of the first time delay VV, the second time delay VV_{PVC1} and the third time delay VV_{PVC2} is preferably shorter than 80 ms, normally shorter than 40 ms. Preferably, the second time delay VV_{PVC1} and the third time delay VV_{PVC2} are set to be shorter than the first time delay VV.

Although not described in more detail here, the device 10 may of course be arranged to operate in a manner known to a person skilled in the art. For example, the device 10 may be arranged to detect evoked responses to delivered pacing pulses and to deliver back-up pulses when necessary. The device 10 can also be arranged to inhibit pacing pulses when detecting intrinsic events. The device 10 can also be arranged with particular timer intervals in order to avoid PMT. The device may thus for example include the +PVARP-function that has been described above.

According to the invention, the device 10 is preferably arranged to operate in the manner that will now be described in connection with Fig 3 A, 3 B and 4.

Fig 3 A illustrates the operation of the device 10 in a first case. The line A represents atrial events, for example events in the right atrium RA. The line 1V relates to events in a first ventricle 1V. The line 2V relates to events in the second ventricle 2V. As has been explained above, the first ventricle is in this case defined as the ventricle which is to be paced first if both ventricles are paced with a first time delay VV. The events shown in Fig 3 A thus occur on a time scale which is indicated by t. Fig 3 A first illustrates that an atrial event, a P-wave, is sensed. After a certain time a pacing pulse 71 is delivered with the first pacing means 18. Also an evoked response 73 is shown on the line 1V. After the first time delay VV a pacing pulse 74 is delivered with the second pacing means 19. Also in this case an evoked response 75 is shown. Later a signal 76 is in this case sensed by the first sensing means 16. Since this signal is typical for an R-wave and is not preceded by any atrial event since the last ventricular events, the signal 76 is categorised as a PVC. Since the signal 76 is sensed by the first sensing means 16 (which relate to the ventricle that is normally paced first), a pacing pulse 77 is delivered by the second pacing means 19 after the second time delay VV_{PVC1}. As will be explained in connection with Fig 4, the pacing pulse 77 could be inhibited in case an event is sensed by the second sensing means 17 during the second time delay VV_{PVC1}. The time delay VV_{PVC1} is set to optimise the synchronisation of the depolarisation of the ventricles. Thereby, the likelihood of an arrhythmia caused by the PVC is reduced. Fig 3 A also shows an evoked response 78 to the pacing pulse 77.

Fig 3 B shows lines corresponding to those of Fig 3 A. The events P, 71, 73, 74, 75 are the same as have been described in connection with Fig 3 A. However, in Fig 3 B, a signal 79 is sensed by the second sensing means 17. This signal 79 is characterised as a PVC, since no intermediate atrial event has occurred since the last ventricular events. Since the PVC 79 is in this case detected by the

second sensing means 17, a pacing pulse 80 is delivered with a third time delay VV_{PVC2} with the first pacing means 18 in order to reduce the risk for an arrhythmia caused by the PVC. In the shown embodiment, the third time delay VV_{PVC2} is set to be substantially equal to 0. This can be beneficial if the PVC is detected be the sensing means that relates to the ventricle that is normally paced last if the device operates with a first time delay VV. The line 1V also shows an evoked response 81.

Fig 4 shows a schematic flow chart of the operation of the device 10 according to an embodiment. First it is determined whether a detected signal is to be categorised as a PVC. If this is not the case, then the normal operation of the device 10 continues. However, in case the signal is typical for a PVC, then it is determined whether the signal is sensed by the first sensing means 16 or the second sensing means 17. The first sensing means 16 relates to the ventricle that is normally paced first. If the PVC-signal is not sensed by the first sensing means 16 (and therefore by the second sensing means 17), then a VV_{PVC2}-timer starts. According to an advantageous embodiment, it is thereby possible to monitor whether a signal is sensed by the first sensing means 16 during the VV_{PVC2} time delay. If no such signal is sensed, then a pacing pulse is delivered by the first pacing means 18 at the time out the third time delay VV_{PVC2}. The device 10 then goes back to normal operation. However, in case a signal is sensed by the first sensing means 16 during the third time delay VV_{PVC2}, then no pacing signal is delivered with the first pacing means 18 at the time out of the third time delay VV_{PVC2}. The device 10 instead goes back to normal operation. According to one embodiment, the third time delay is set to be substantially equal to 0.

According to an alternative embodiment, it is not necessary that the device is arranged with a timer for the third time delay VV_{PVC2}. Instead, a pacing pulse is delivered immediately with the first pacing means 18 if the PVC-signal is sensed by the second sensing means 17.

In case the PVC-signal is sensed by the first sensing means 16, then a VV_{PVC1}-timer starts. According to an advantageous embodiment, it is thereby possible to monitor whether a signal is sensed by the second sensing means 17 during the VV_{PVC1} time delay. If no such signal is sensed, then a pacing pulse is delivered with the second pacing means 19 at the time out the second time delay VV_{PVC1}. However, in case a signal is sensed by the second sensing means 17 during the second time delay VV_{PVC1}, then no pacing signal is delivered by the second pacing means 19 at the time out of the second time delay VV_{PVC1}. The device 10 instead goes back to normal operation.

An example of a heart stimulating system according to the invention is shown in connection with Fig 1. The system thus includes the heart stimulating device 10 together with at least a first lead 30 and a second lead 40. A first pacing electrode 31, 32 is arranged on the first lead 30 and a second pacing electrode 41, 42 is arranged on the second lead 40. The first pacing electrode 31, 32 is preferably also used as the first sensing electrode 31, 32. Analogously, the second sensing electrode 41, 42 is the same electrode as the second pacing electrode 41, 42.

The device is preferably used according to the invention such that the system is implanted in a human or animal being, wherein the first pacing electrode 31, 32 is positioned in or at a first ventricle 1V of the heart of the human or animal being and the second pacing electrode 41, 42 is positioned in or at the second ventricle 2V of the heart as exemplified in Fig 1. The device is used, as described above, to react to a PVC in a manner such that the risk for arrhythmia is reduced. Preferably, the system is used on a human or animal being suffering from congestive heart failure, for example caused by a bundle branch block.

The invention is not limited to the described embodiments but may be varied and modified within the scope of the following claims.

PRV 03-02-18

Claims

1. An implantable heart stimulating device (10) including a control circuit (14) comprising:

first pacing means (18) adapted to be connected to a first pacing electrode (31, 32) suited to be positioned in or at a first ventricle (1V) of a heart such that said first pacing means (18) are able to deliver pacing pulses to said first pacing electrode (31, 32) in order to be able to pace said first ventricle (1V);

first sensing means (16) adapted to be connected to a first sensing electrode (31, 32) suited to be positioned in or at said first ventricle (1V) of the heart so as to transfer signals to said first sensing means (16) such that said first sensing means (16) are able to sense said first ventricle (1V);

second pacing means (19) adapted to be connected to a second pacing electrode (41, 42) suited to be positioned in or at a second ventricle (2V) of the heart such that said second pacing means (19) are able to deliver pacing pulses to said second pacing electrode (41,42) in order to be able to pace said second ventricle (2V);

second sensing means (17) adapted to be connected to a second sensing electrode (41, 42) suited to be positioned in or at said second ventricle (2V) of the heart so as to transfer signals to said second sensing means (17) such that said second sensing means (17) are able to sense said second ventricle (2V);

said control circuit (14) being arranged to be able to operate with time cycles corresponding to normal heart cycles;

said control circuit (14) being arranged to be able to operate with a first time delay (VV) and to, within one and the same of said time cycles, being able to first pace and/or sense with said first pacing means (18) or said first sensing means (16) and then deliver a pacing pulse with said second (19) pacing means with said first time delay (VV);

said control circuit (14) also being arranged to include a criterion with which a signal that is sensed by said first (16) or second (17) sensing means, and which fulfils said criterion, is characterised as belonging to a first category of signals typical for a premature ventricular contraction (PVC),

characterised in that

said control circuit (14) is also arranged to operate with a second time delay (VV_{PVC1}) and/or a third time delay (VV_{PVC2}), and to, within one of said time cycles, being able to first sense with one of said first (16) and second (17) sensing means and then, at least if a predefined pacing rule is fulfilled, deliver a pacing pulse, with said second time delay (VV_{PVC1}) with the second pacing means (19) if the sensing was done with said first sensing means (16) or with said third time delay (VV_{PVC2}) with the first pacing means (18) if the sensing was done with said second sensing means (17).

2. An implantable heart stimulating device according to claim 1, wherein the control circuit (14) is arranged to be able to perform the following steps:

determine whether a signal sensed by said first (16) or second (17) sensing means belongs to said first category, and, if this is the case, deliver a pacing pulse, in accordance with said predefined pacing rule, with said first pacing means (18) if said signal in said first category was sensed by said second sensing means (17) and with said second pacing means (19) if said signal in said first category was sensed by said first sensing means (16).

3. An implantable heart stimulating device according to claim 2, wherein the control circuit (14) is arranged such that said predetermined pacing rule implies that if said signal in said first category is sensed by said first sensing means (16), then the pacing pulse delivered by said second pacing means (19) is delivered with said second time delay (VV_{PVC1}).

4. An implantable heart stimulating device according to claim 3, wherein the control circuit (14) is arranged such that after that said signal in said first category is sensed by said first sensing means (16), the control circuit (14) monitors whether a corresponding signal is sensed by said second sensing means (17), and if such a signal is sensed by said second sensing means (17) during said second time delay (VV_{PVC1}), then the delivery of said pacing pulse with said second pacing means (19) is inhibited.

5. An implantable heart stimulating device according to any of the claims 2-4, wherein the control circuit (14) is arranged such that said predetermined pacing rule implies that if said signal in said first category is sensed by said second sensing means (17), then the pacing pulse delivered by said first pacing means (18) is delivered with said third time delay (VV_{PVC2}).

6. An implantable heart stimulating device according to claim 5, wherein the control circuit (14) is arranged such that after that said signal in said first category is sensed by said second sensing means (17), the control circuit (14) monitors whether a corresponding signal is sensed by said first sensing means (16), and if such a signal is sensed by said first sensing means (16) during said third time delay (VV_{PVC2}), then the delivery of said pacing pulse with said first pacing means (18) is inhibited.

7. An implantable heart stimulating device according to any of the preceding claims, wherein the control circuit (14) is arranged such that each of said first (VV), second (VV_{PVC1}) and third (VV_{PVC2}) time delays is shorter than 80ms.

8. An implantable heart stimulating device according to any of the preceding claims, wherein the control circuit (14) is arranged such that said first time delay (VV) is different from one or both of said second time delay (VV_{PVC1}) and said third time delay (VV_{PVC2}).

9. An implantable heart stimulating device according to claim 8, wherein said first time delay (VV) is longer than one or both of said second time delay (VV_{PVC1}) and said third time delay (VV_{PVC2}).

10. An implantable heart stimulating device according to any of the above claims, wherein the control circuit (14) is arranged such that said third time delay (VV_{PVC2}) is substantially equal to 0.

11. An implantable heart stimulating device according to any of the preceding claims, comprising means (22, 24, 23, 25) adapted to be able to also sense and/or pace an atrium of said heart.

12. An implantable heart stimulating device according to claim 11, wherein said control circuit (14) is arranged such that said criterion is that either a signal is sensed by said first (16) sensing means after a previous sensed or paced or inhibited event relating to said first (16, 18) sensing or pacing means without any intermediate sensed or paced event by said means (22, 24, 23, 25) for sensing and pacing an atrium or that a signal is sensed by said second (17) sensing means after a previous sensed or paced or inhibited event relating to said second (17, 19) sensing or pacing means without any intermediate sensed or paced event by said means (22, 24, 23, 25) for sensing and pacing an atrium.

13. An implantable heart stimulating system comprising:

an implantable heart stimulating device (10) according to any of the preceding claims, and

a first (30) and a second (40) lead connected to said device, wherein said first pacing electrode (31, 32) is arranged on said first lead (30) and said second pacing electrode (41, 42) is arranged on said second lead (40).

14. An implantable heart stimulating system according to claim 13, wherein said first sensing electrode (31, 32) is the same electrode as said first pacing electrode (31, 32) and wherein said second sensing electrode (41, 42) is the same electrode as said second pacing electrode (41, 42).

15. Use of an implantable heart stimulating system according to any of the claims 13 and 14, wherein said system is implanted in a human or animal being and wherein said first pacing electrode (31, 32) is positioned in or at a first ventricle (1V) of the heart of said human or animal being and wherein said second pacing electrode (41, 42) is positioned in or at the second ventricle (2V) of said heart.

16. Use according to claim 15, wherein the heart stimulating system is used to react to a premature ventricular contraction such that the risk for arrhythmia is reduced.

17. Use according to claim 15 or 16, wherein the heart stimulating system is used on a human or animal being suffering from congestive heart failure.

18. Use according to any of the claims 15-17, wherein said human or animal being suffers from a bundle branch block.

Abstract

The invention concerns an implantable bi-ventricular heart stimulating device (10) arranged to, within a time cycle, be able to deliver pacing pules with both a first (18) and a second (19) pacing means with a first time delay (VV) between these pacing pulses. The device (10) is also arranged to include a criterion with which a signal typical for a premature ventricular contraction (PVC) is detected. The device is also arranged to operate with a second time delay (VV_{PVC1}) and/or with a third time delay (VV_{PVC2}), and to, at least if a predefined pacing rule is fulfilled, deliver a pacing pulse with said second time delay (VV_{PVC1}) or said third time delay (VV_{PVC2}). The invention also concerns a system including such a device (10) as well as a use of this system. With the invention the risk for arrhythmia in connection with a PVC is reduced.

(Fig 3 A)

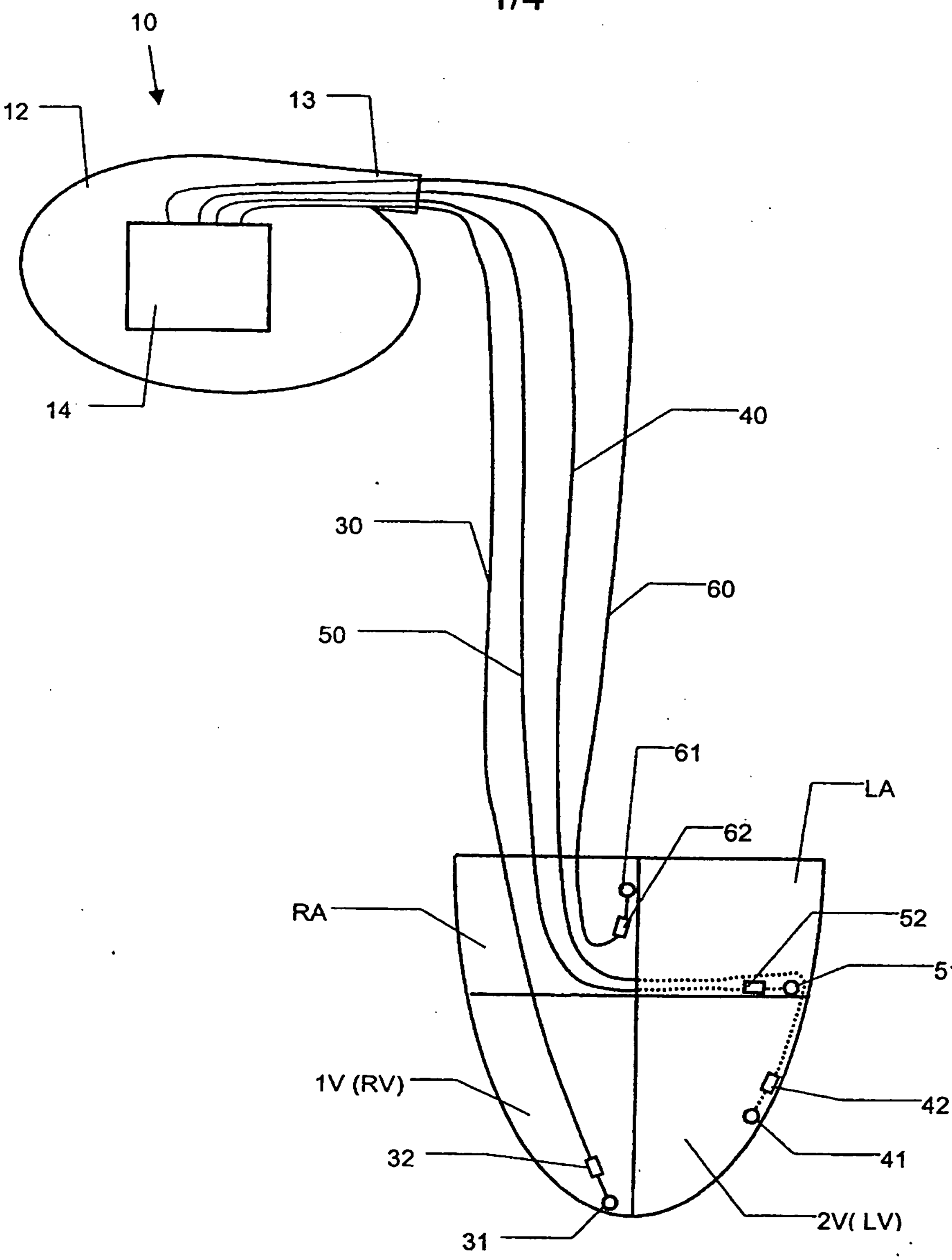

FIG 1

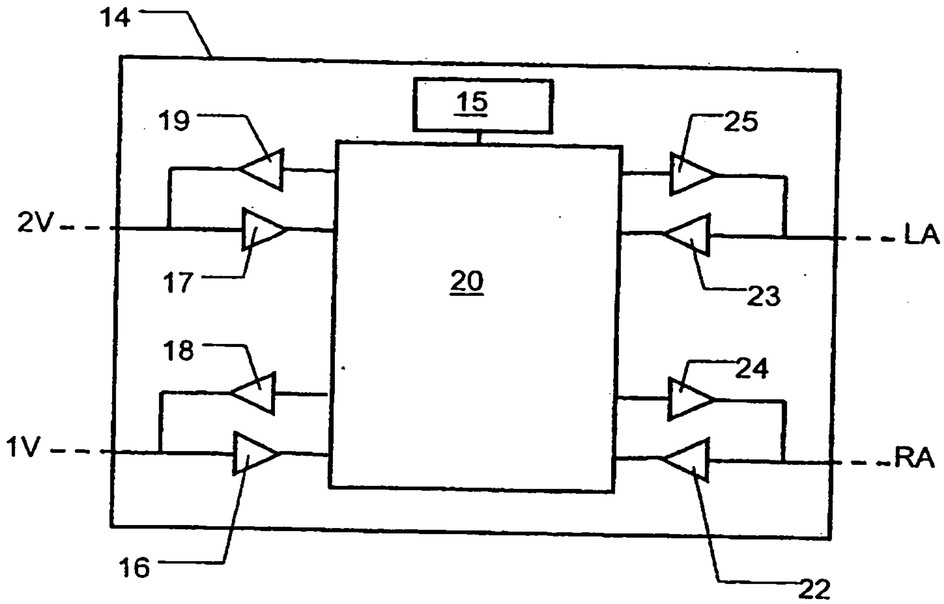

FIG 2

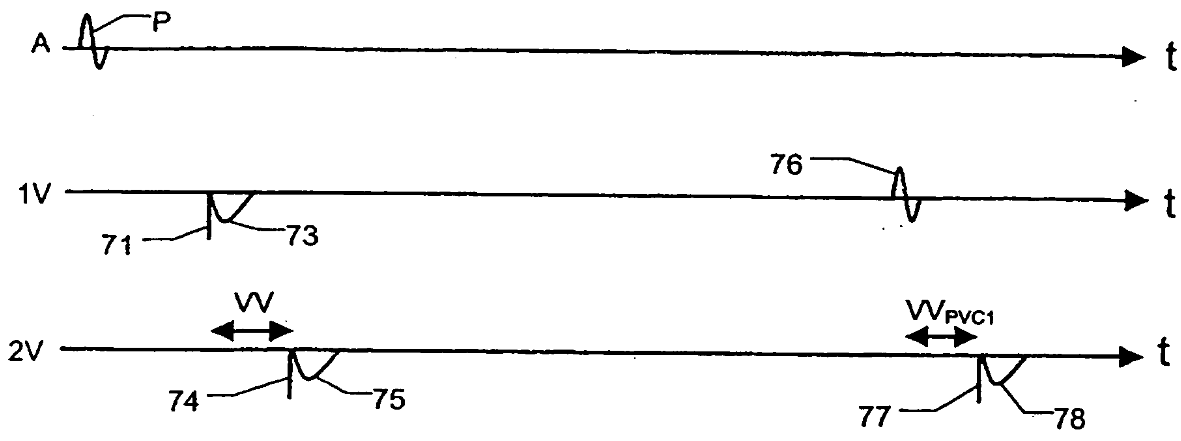
P
A
t
76
1V
t
71
73
VV
VV$_{PVC1}$
2V
t
74
75
77
78

FIG 3A

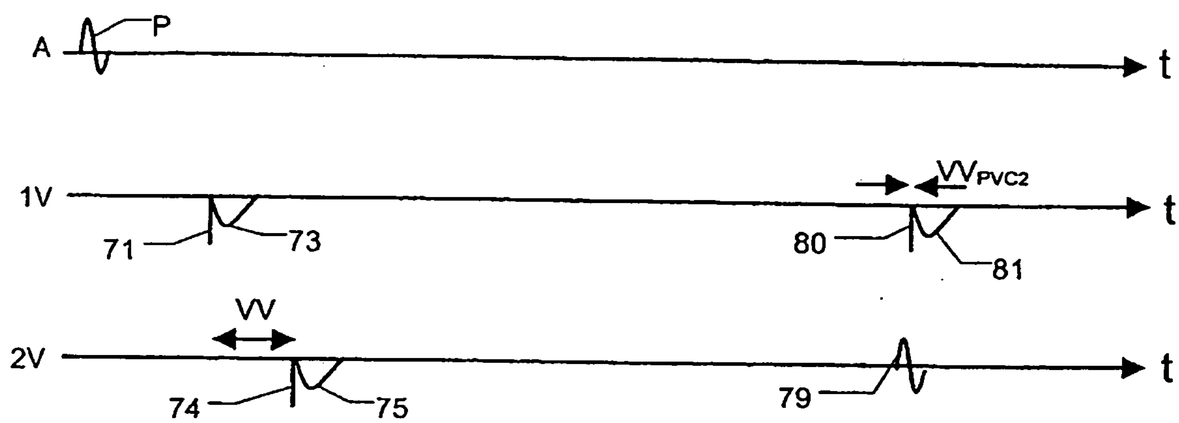
P
A
t
VV$_{PVC2}$
1V
t
71
73
80
81
VV
2V
t
74
75
79

FIG 3B

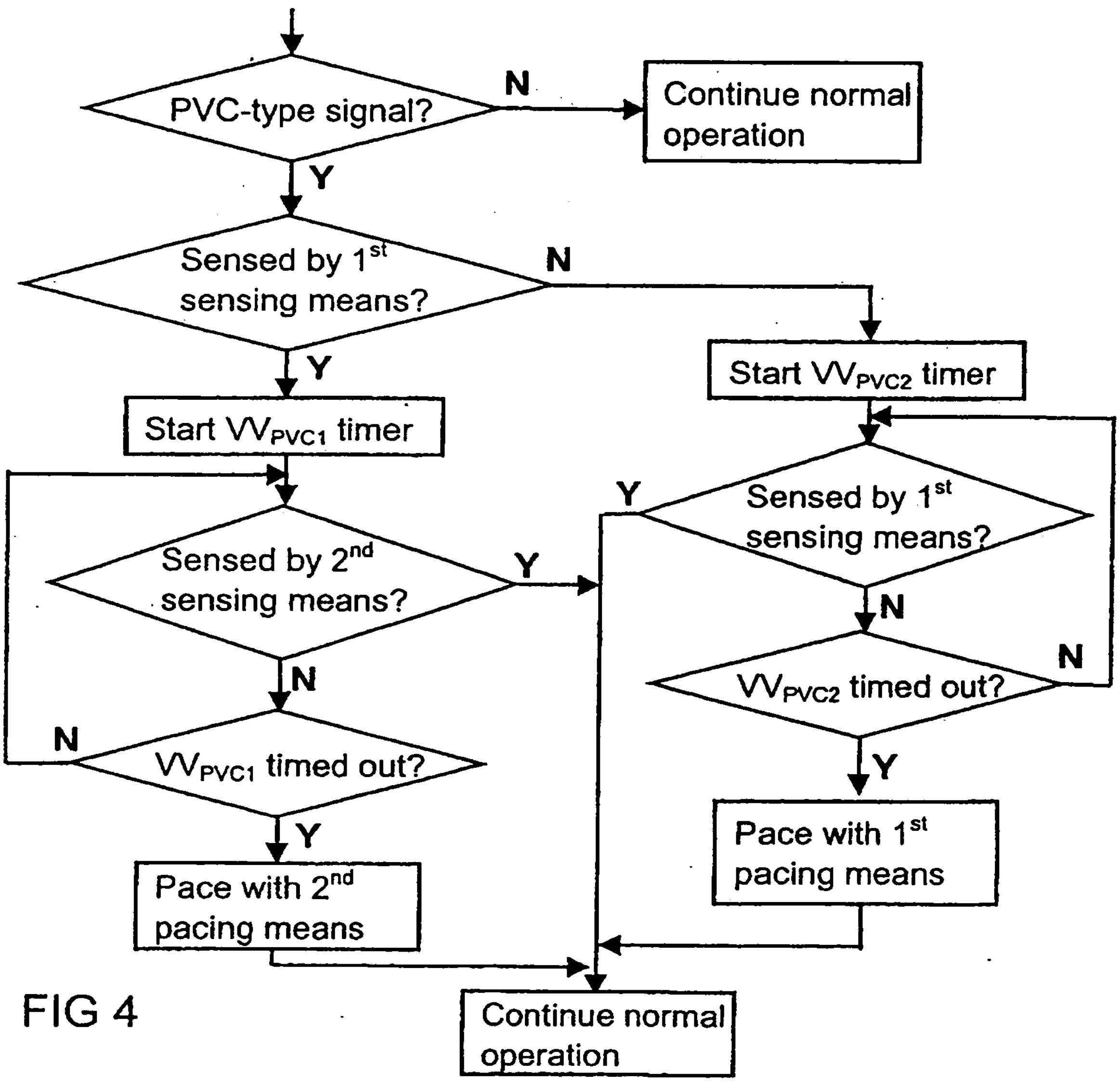
PVC-type signal?
N
Continue normal operation
Y
Sensed by 1st sensing means?
N
Y
Start VV_PVC1 timer
Start VV_PVC2 timer
Sensed by 2nd sensing means?
Y
Sensed by 1st sensing means?
Y
N
N
VV_PVC2 timed out?
N
N
VV_PVC1 timed out?
Y
Y
Pace with 2nd pacing means
Pace with 1st pacing means
Continue normal operation

FIG 4